NASA GRC Low Temperature Electronics Program

In-house Testing of JPL BGA Electronic Board # 1

Preliminary Report

A JPL-furnished electronic board (number 1), populated with discrete devices, surface-mount integrated circuits, and ball grid array (BGA), was subjected to thermal cycling using the following temperature & time profile:

1. Start at 25 °C.
2. Ramp to 100 °C at a rate of 5 °C/minute.
3. Hold at 100 °C for 10 minutes.
4. Ramp to –185 °C at a rate of 5 °C/minute.
5. Hold at –185 °C for 10 minutes.
6. Ramp to 25 °C at a rate of 5 °C/ minute.

The testing of the board was performed in four phases.

Phase 1: Two thermal cycles
Phase 2: Three more thermal cycles.
Phase 3: Five more thermal cycles.
Phase 4: One more thermal cycle.

Throughout these tests, the board was characterized in terms of:

- Electrical continuity: This was monitored by measuring the voltage drop across each pair of the seven BGA contact pads. The voltage drops were recorded each minute throughout all four phases of the tests. The test setup and procedure involved the use of a Source Measure Unit, which delivered an output voltage of 1.0 Vdc and sensed the total circuit current flow. A 330 Ω resistor was used in series with each BGA pair to limit the current flow. An HP data acquisition and switching unit was used to scan and capture the voltage drop across the BGA contact pairs for all seven BGA channels.

- Temperature-time profile: This was registered by two type T thermocouples taped in central locations on the board.

- Interconnect reliability: This was accomplished by visual inspection of solder joints and device leads after the end of each test phase. A 40 X stereo microscope was used to check for cracking, open contacts, and other temperature-induced defects.

Observations and Comments

- Visual inspections of the board, that were performed at the end of each of the four test phases, revealed that no noticeable physical changes were produced as a result of the thermal cycling.

- The resistance of each BGA pair changed as a function of test temperature. When temperature increased, BGA pair resistance increased; when temperature decreased, BGA pair resistance decreased. This change was transitory, however, because the resistance of each BGA pair returned to its original room temperature value at the conclusion of each test.

- The resistance of each BGA pair varied linearly with temperature, but each BGA pair showed a different slope. Note that the value of each BGA pair resistance at a given test temperature was not influenced by the direction of temperature change, i.e. increasing or decreasing. (It is suspected that part of the data reported for BGA pair 3-3 was not very stable due to loose connections).

- In conclusion, the electronic board has survived a total of eleven cycles in the temperature range of +100 °C to –185 °C without undergoing any noticeable change in terms of BGA electrical continuity and physical integrity.

Richard L. Patterson
Manager, Low Temperature Electronics
NASA Glenn Research Center

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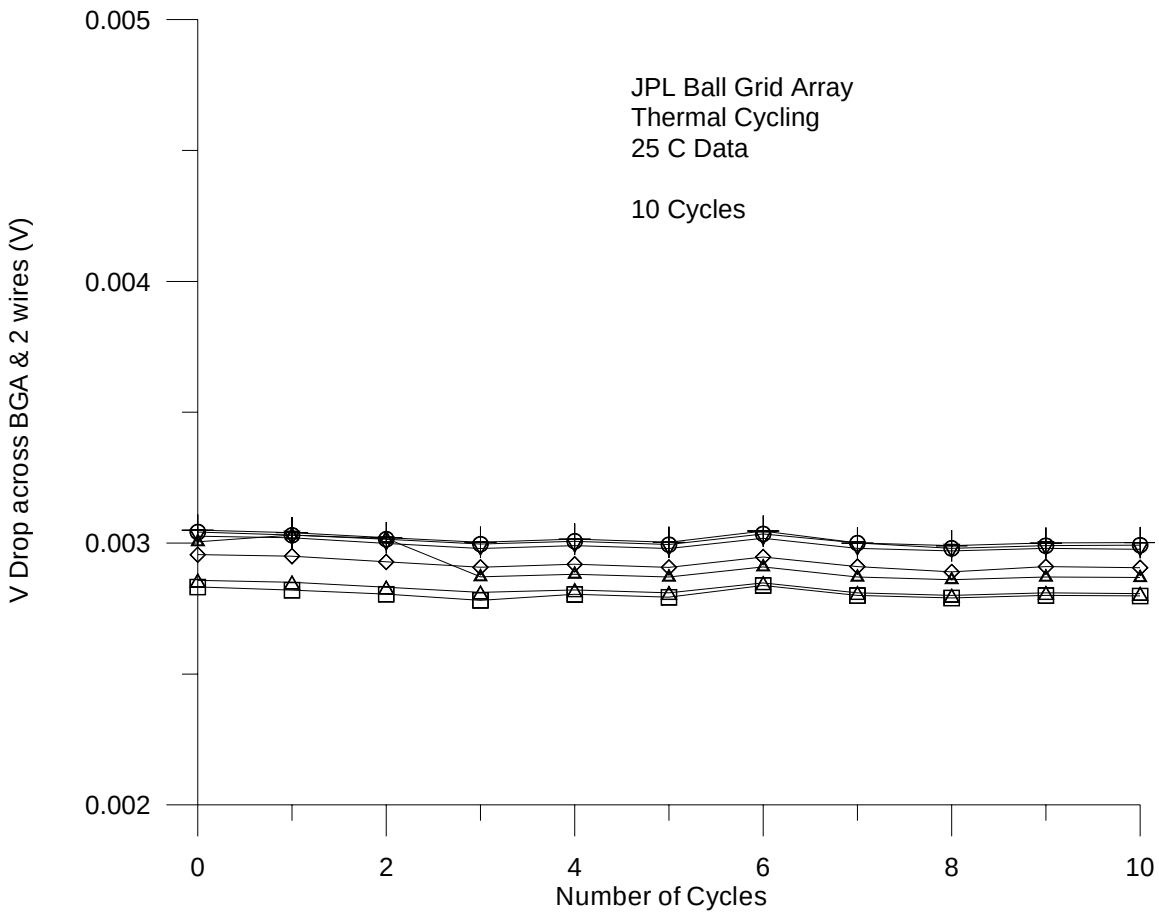
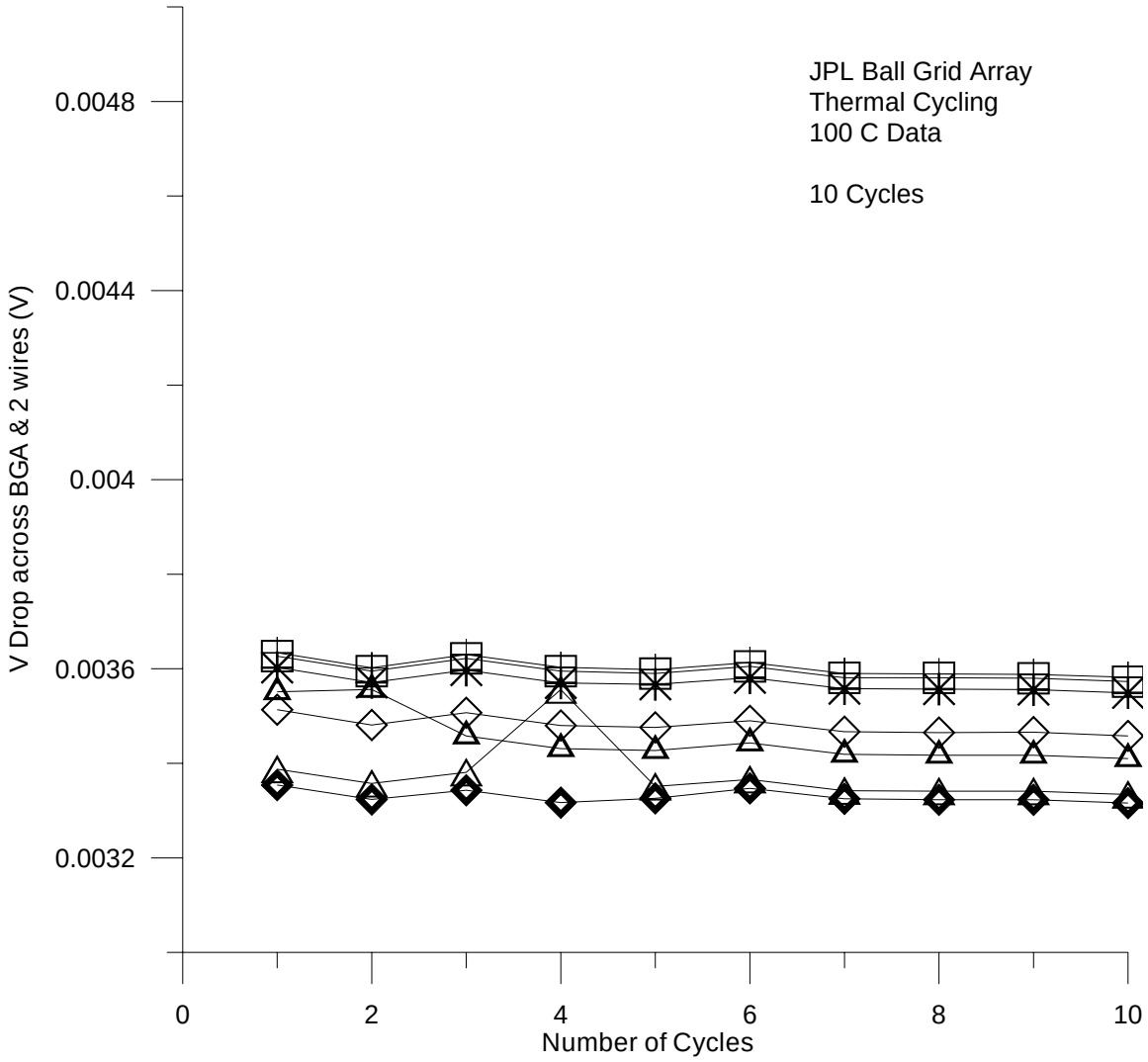
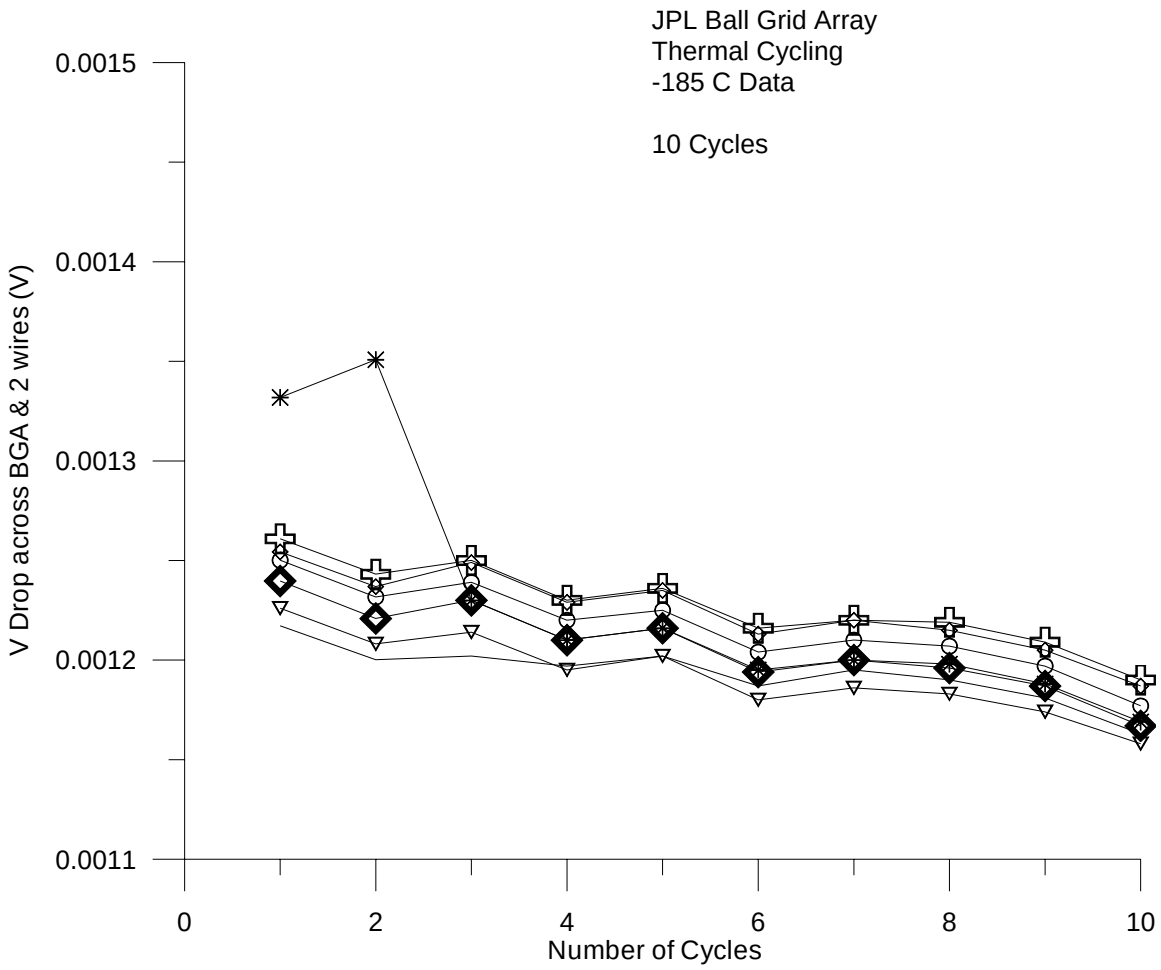
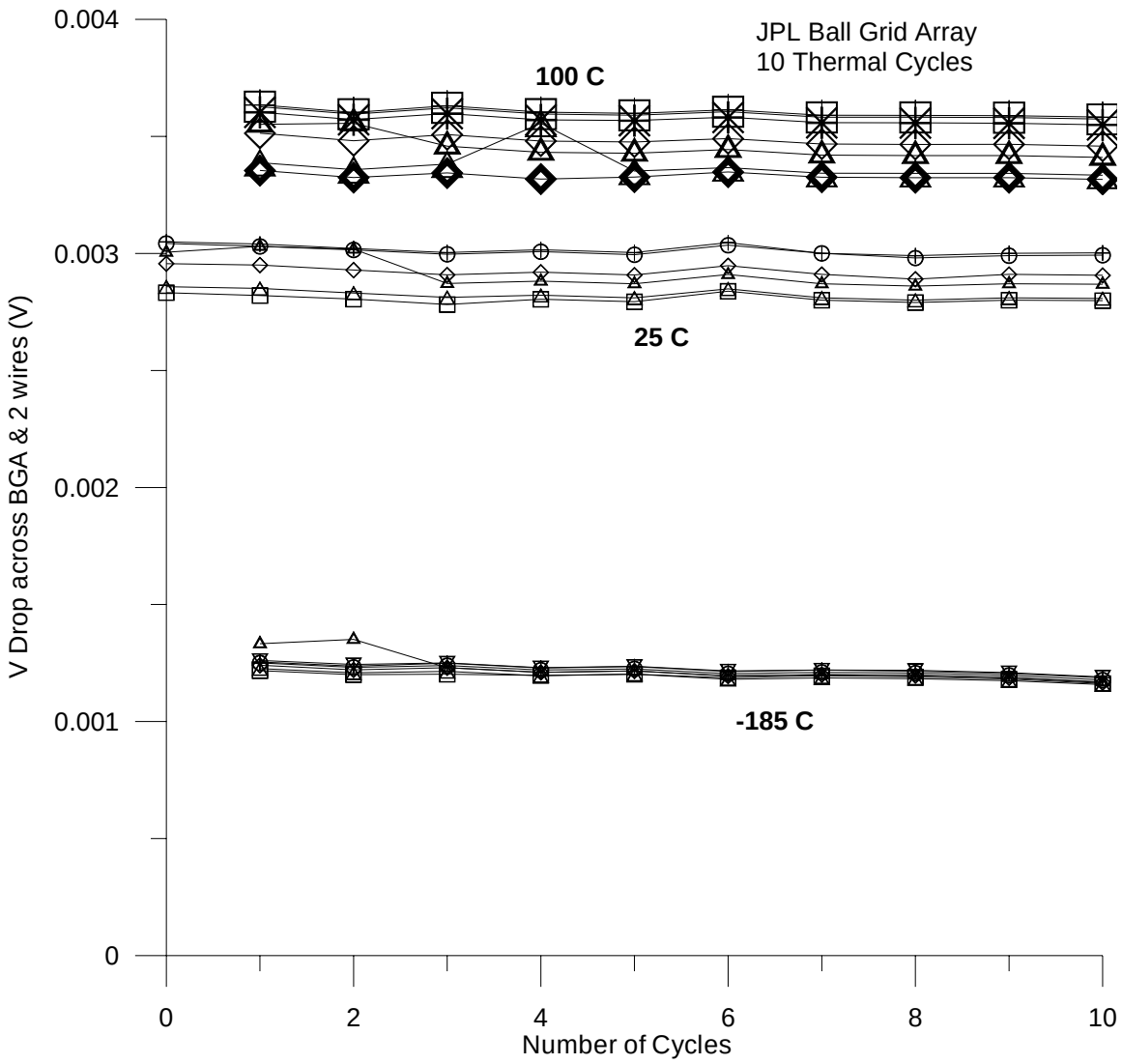
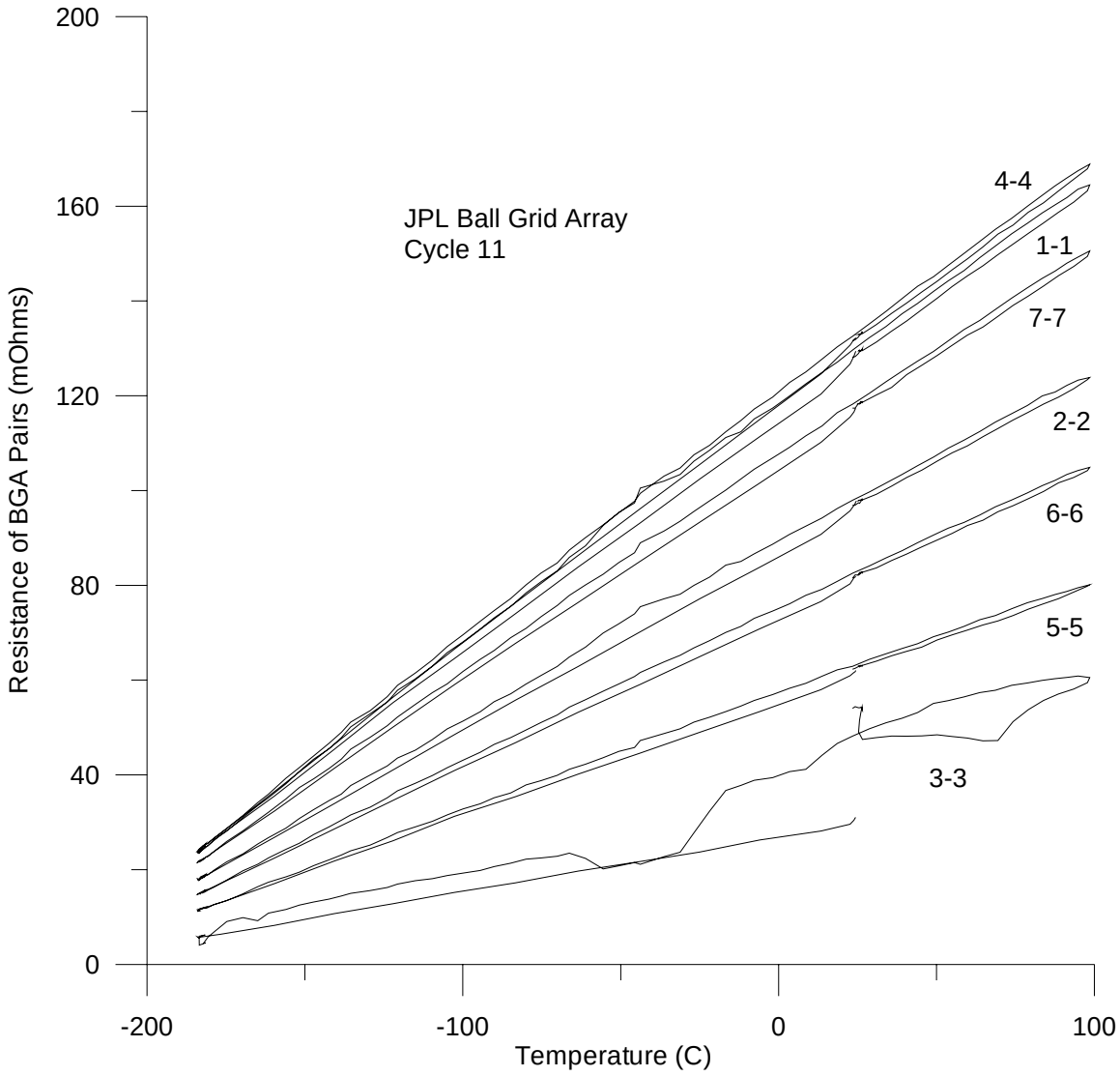

JPL Ball Grid Array
Thermal Cycling
25 C Data
10 Cycles
V Drop across BGA & 2 wires (V)
0.005
0.004
0.003
0.002
0
2
4
6
8
10
Number of Cycles


JPL Ball Grid Array
Thermal Cycling
100 C Data
10 Cycles
V Drop across BGA & 2 wires (V)
0.0048
0.0044
0.004
0.0036
0.0032
0
2
4
6
8
10
Number of Cycles


JPL Ball Grid Array
Thermal Cycling
-185 C Data
10 Cycles
V Drop across BGA & 2 wires (V)
0.0015
0.0014
0.0013
0.0012
0.0011
0
2
4
6
8
10
Number of Cycles


JPL Ball Grid Array
10 Thermal Cycles
100 C
25 C
-185 C
V Drop across BGA & 2 wires (V)
0.004
0.003
0.002
0.001
0
0
2
4
6
8
10
Number of Cycles


JPL Ball Grid Array
Cycle 11
Resistance of BGA Pairs (mOhms)
Temperature (C)
200
160
120
80
40
0
-200
-100
0
100
4-4
1-1
7-7
2-2
6-6
5-5
3-3